Measurements of prompt and non-prompt D meson production and anisotropy in Pb-Pb at $\sqrt{s_{NN}} = 5.02$ TeV with ALICE

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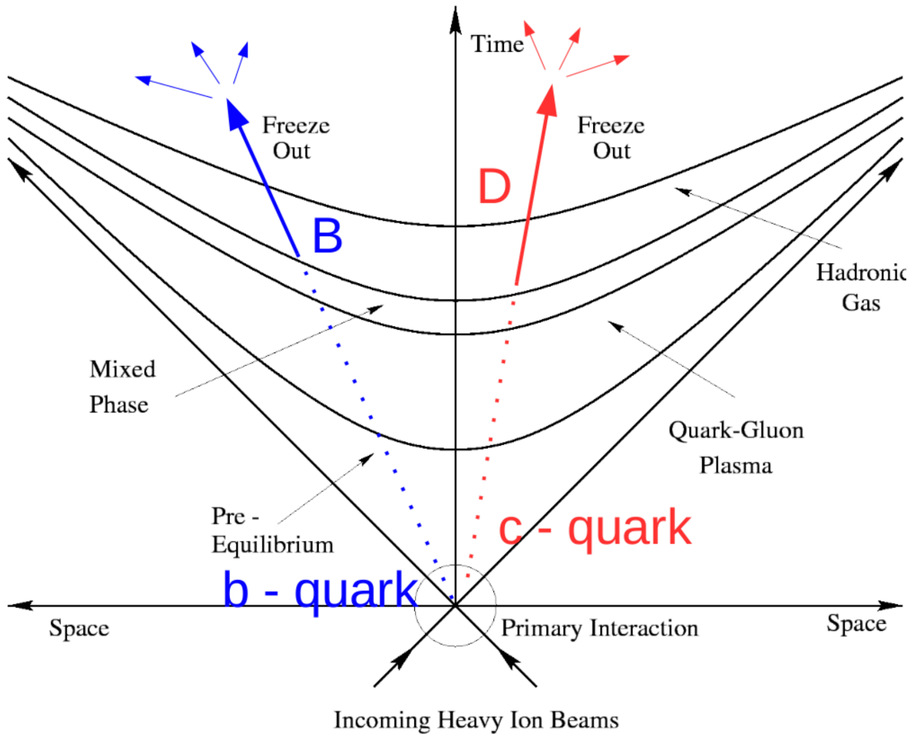
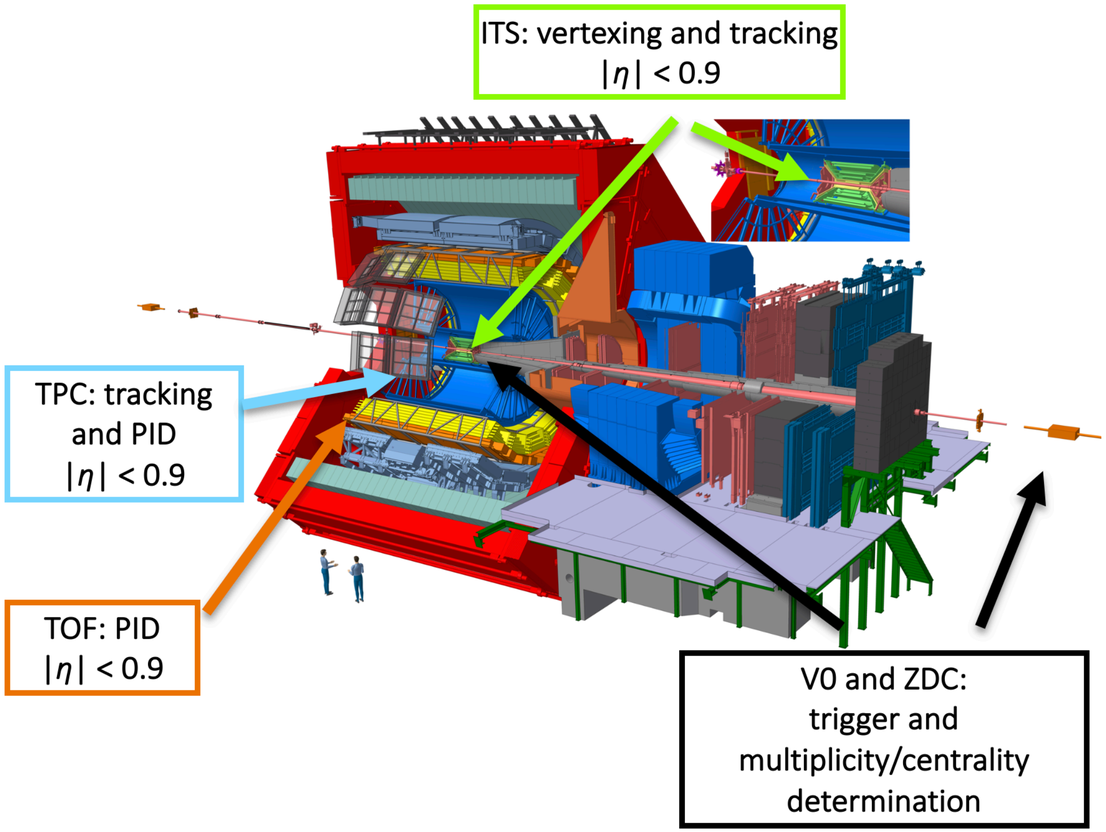
Introduction



- The heavy-flavor quarks (charm, beauty) are mainly produced in hard partonic scattering processes, in the early stage of system evolution after the collision
- Shorter formation time than the QGP, probing the full evolution of the quark-gluon matter by interacting with the medium constituents

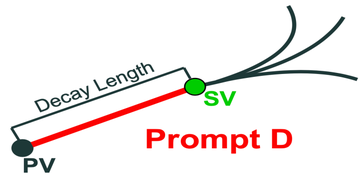


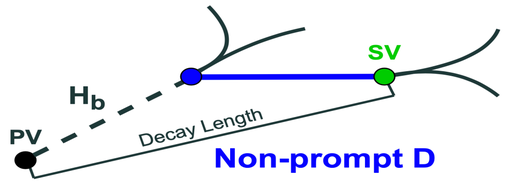
- **Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV collected in 2018**
- **92.5M events for 0-10%, 80.8M events for 30-50%**

- $D^0 \rightarrow K^-\pi^+$, **BR ~ 3.95%**
- $D^+ \rightarrow K^-\pi^+\pi^+$, **BR ~ 0.38%**
- $D_s^+ \rightarrow K^-K^+\pi^+$, **BR ~ 5.39%**
- $D^* \rightarrow D^0\pi^+$, **BR ~ 67.7%**

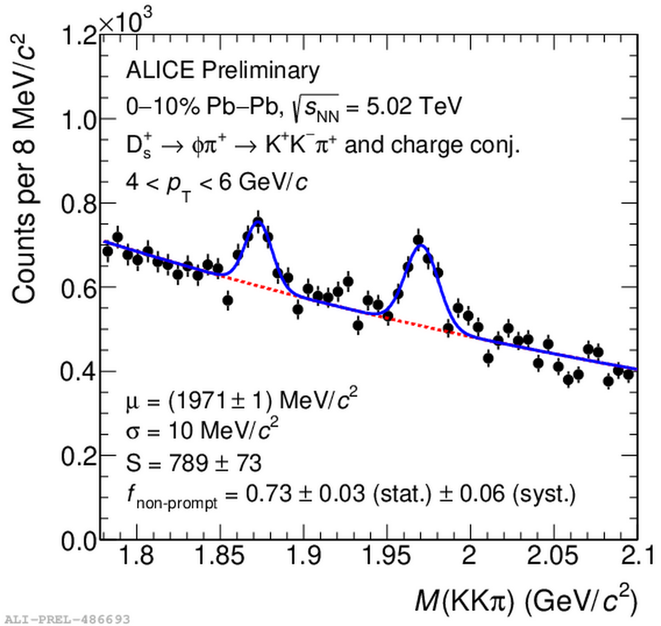
Signal extraction

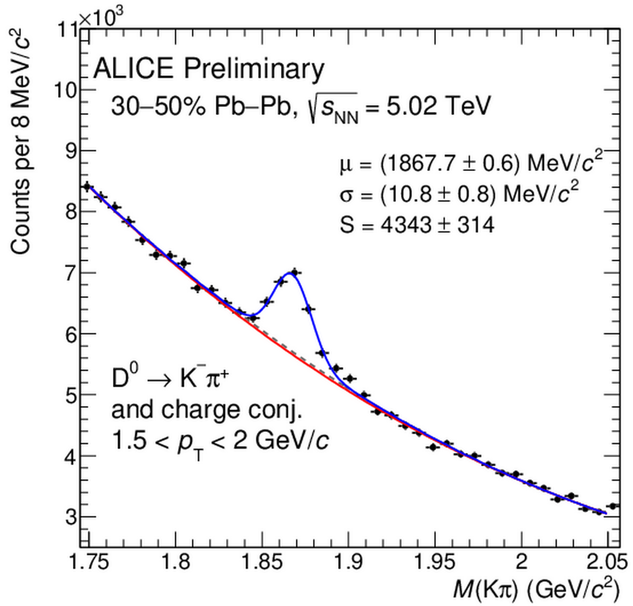
- Reconstruction of D meson decay vertices around few hundreds μm by combining pairs/triplets of tracks
- Particle identification (PID) of decay tracks and geometrical selection of displaced decay-vertex topology
- Signal was extracted via an invariant mass analysis
- Efficiency correction with Monte Carlo simulations [1,2] and beauty feed-down subtraction based on FONLL pQCD calculations[3]
- **XGBoost multi-class** classifier with kinematic, topological and PID variables as input to separate prompt, non-prompt and background candidates[4]

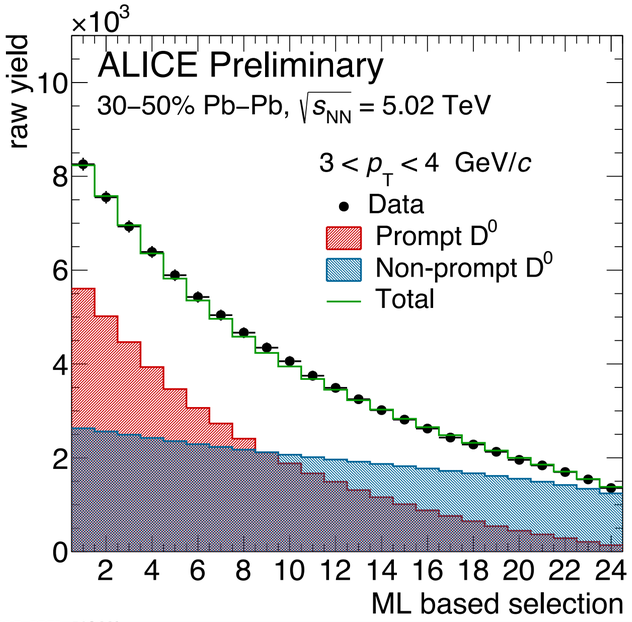




- Prompt and non-prompt D^0 contribution was subtracted exploiting a **minimum χ^2 approach** with variation of the ML-based selection on the raw yield







Reference: [1] PRD 44 (1991) 3501 [2] JHEP 0605 (2006) 026 [3] JHEP 9805 (1998) 007 [4]JHEP 05 (2021) 220

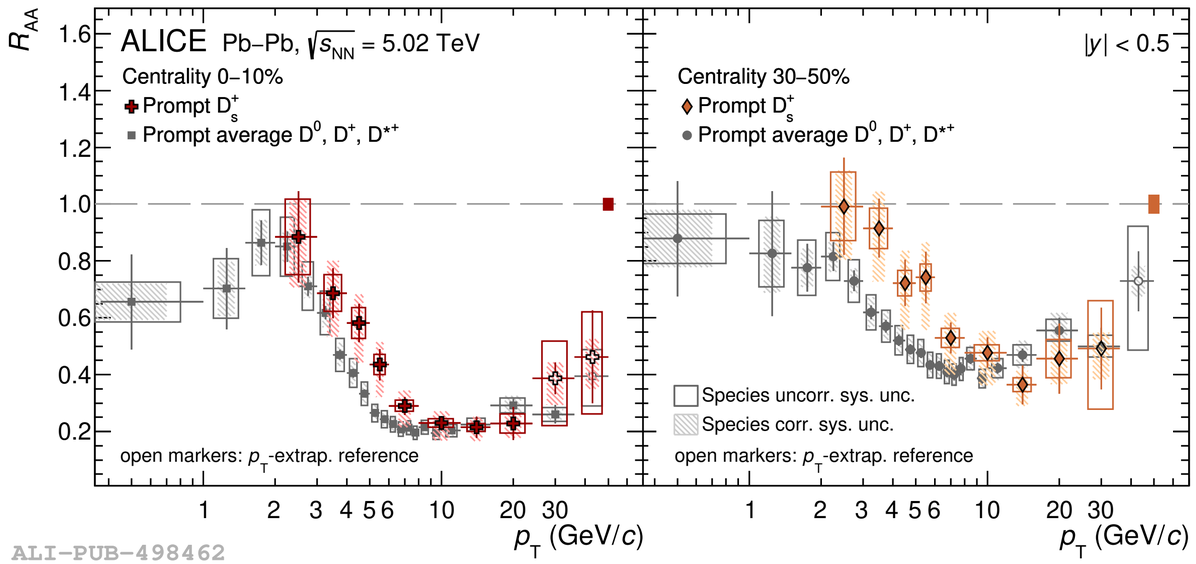
Nuclear modification factor R_{AA}

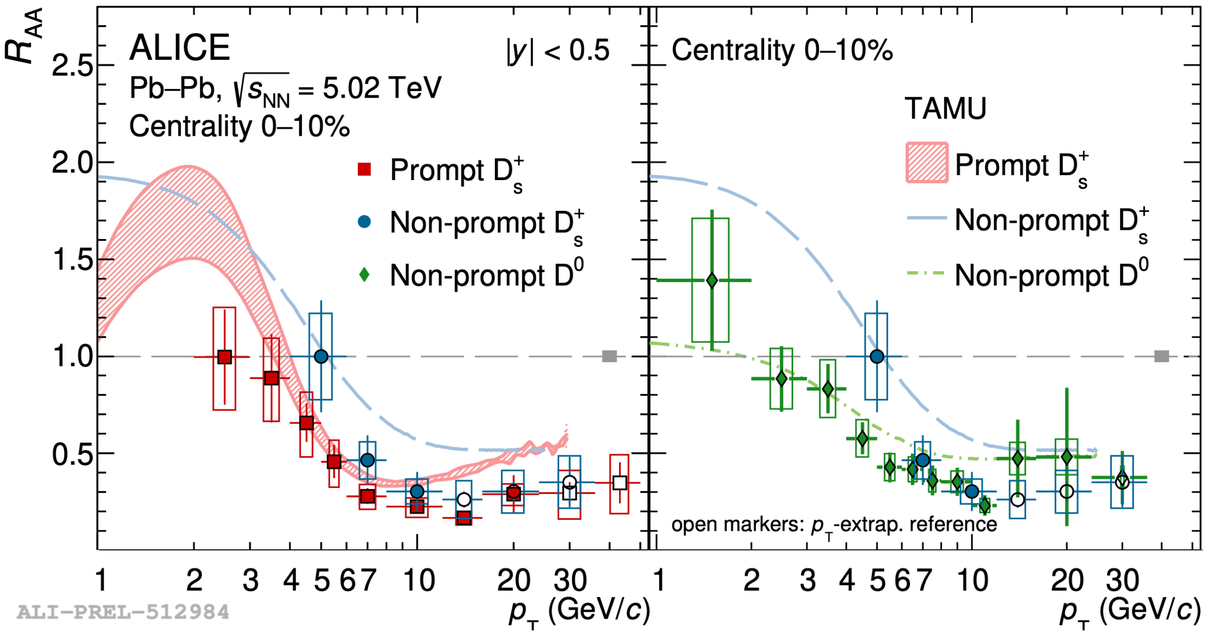
$$R_{AA} = \frac{1}{< T_{AA} >} \frac{dN_{AA}/dp_T}{d\sigma_{pp}/dp_T}$$

- $<T_{AA}>$ is the average nuclear overlap function
- $d\sigma_{pp}/dp_T$ is the cross-section measured in pp collisions

- **Prompt**[5][6]**:**
  - High p_T: R_{AA} of D_s^+ and non-strange D mesons are compatible
  - Low p_T: R_{AA} of D_s^+ is systematically higher than that of non-strange D mesons but compatible within about one standard deviation
- **Non-prompt**[7]**:**
  - $p_T < 6$ GeV/c:
    - ➡ $R_{AA}^{non-prompt}(D_s^+) > R_{AA}^{prompt}(D_s^+)$
    - ➡ $R_{AA}^{non-prompt}(D_s^+) > R_{AA}^{non-prompt}(D^0)$

  even though they are compatible within uncertainties.





Azimuthal anisotropy

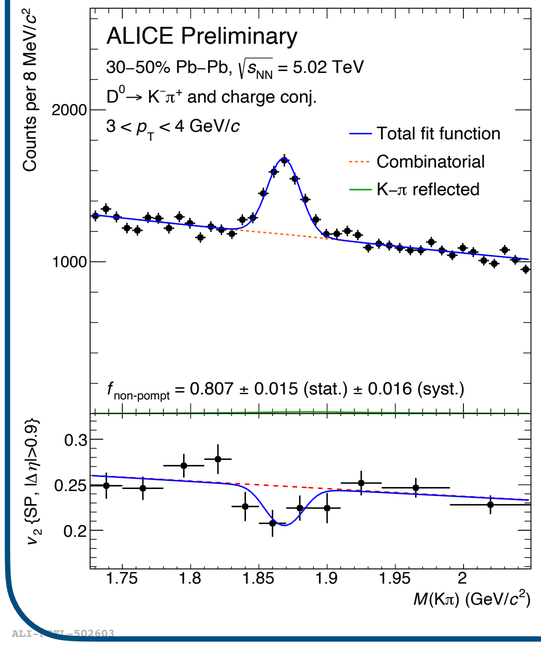
- The second-order coefficient of the Fourier expansion for the azimuthal distribution of particle momenta:

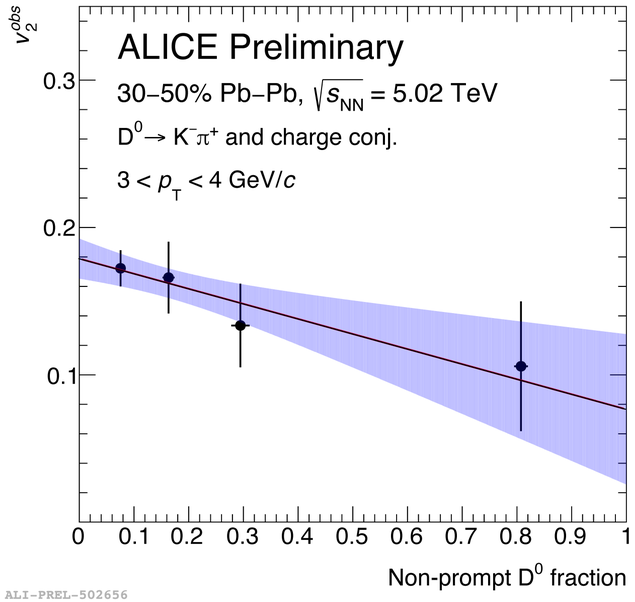
$$v_2 = < \cos[2(\varphi - \psi_2)] >$$

- **Scalar product method** is based on the measurement of the Q-vectors, The v_2 of signal is extracted via a simultaneous fit of v2(mass) and mass:

$$v_2(M_{k\pi}) = \frac{S(M_{k\pi}) \cdot v_2^s + B(M_{k\pi}) \cdot v_2^B(M_{k\pi}))}{S(M_{k\pi}) + B(M_{k\pi})}$$

- Non-prompt D^0 v_2 evaluated by linear fitting of v_2(observed) versus $f_{\text{non-prompt}}$[8]





- v_2 measurement of heavy quark:
  - ➡ test degree of thermalization (low p_T)
  - ➡ coalescence (intermediate p_T)
  - ➡ path-length dependence of energy loss (high p_T)
- **Prompt**[9]**:**
  - Heavy-quark transport in medium with realistic evolution can fairly describe the data
- **Non-prompt:**
  - Hint of non-prompt D^0 $v_2 > 0$

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